Introduction

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A Wake-Up Call to Inequality

The energy transition is an unprecedented challenge for the world. It is unprecedented in its global ambition and in its complexity. In the United Nations Agenda for Sustainable Development (UN, 2015a) it is formulated as 'Achieving Sustainable Energy for All'. While it is only one of the seventeen Sustainable Development Goals to be accomplished by 2030, the agenda emphasises that the Sustainable Development Goals are strongly interrelated. The goal of achieving sustainable energy for all is crucial indeed in achieving many of the other development goals. Health, food security, gender equality, education, economic development and other sustainable development goals critically depend on access to clean, affordable and reliable energy services.

Sustainable energy for all implies access to energy services for all world citizens. The International Energy Agency (IEA) defines energy access as "a household having reliable and affordable access to both clean cooking facilities and to electricity, which is enough to supply a basic bundle of energy services initially, and then an increasing level of electricity over time to reach the regional average" (IEA, 2020a). For electricity, a basic bundle of energy services means, at a minimum, several lightbulbs, task lighting (such as a flashlight), phone charging and a radio. This minimum service level covers only bare necessities. Most world citizens need a lot more electricity to meet their energy service demands. Hence, the IEA added the notion of regional average to indicate that the minimum energy service level that defines energy access also depends on where and how people live. The minimum

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energy requirements may differ for city residents and rural dwellers, they depend on the state of economic development of the country or region and they are defined by geographic conditions. For instance, people living in a cold climate know that their life may literally depend on adequate heating services during winter time.

Between now and 2030, there is still a long way to go. Since 2000, the number of people without access to electricity has declined from 1.7 billion to 1.1 billion in 2016 and to 770 million in 2019 (IEA, 2020b). This remarkable progress was mainly achieved by grid expansion and new power generation capacity on the basis of fossil fuels. However, although electricity access is improving and the contribution of renewable energy sources is rapidly increasing, it still is a formidable challenge to secure access to electricity for the entire world population by 2030. This is not only about securing a bundle of essential energy services for households, but also about the demand for electricity in industry, the agricultural sector, and the service sectors of the economy. Even with the most energy efficient technologies currently available, industry and services need grid-based access to be productive.

Even more urgent than access to electricity, is access to affordable and cleaner fuels for cooking and heating. In sub-Saharan Africa and remote regions of Asia, many countries still rely on solid biomass, which in practice often implies that women and children spend hours per day to collect firewood. This reduces their opportunities for education and economic activities. Moreover, the indoor use of firewood and other poor-quality fuels for cooking or heating has detrimental health effects. Worldwide, close to 4 million premature deaths per year are attributed to the indoor use of polluting cooking and heating fuels (World Health Organization, 2018).

While installed capacity for power generation from renewable energy sources is rapidly increasing, the energy transition challenge involves more than decarbonising the electricity system. It also affects the provision of fuels for cooking, heating and transport services. Electricity is by far not the largest part of the final energy consumption. For the world, the share of electricity in the total final energy consumption amounted to 19.3% in 2018 (IEA, 2020c). In the EU 27, in 2018, the share of electricity in the total final energy consumption amounted to 20.8%, while petroleum products represented a share of 40.8%, and natural gas a share of 20.8% (European Commission, 2019). In the Netherlands, the share of natural gas in the 2018 final energy consumption amounted to 34.1%, far more than anywhere else in the EU 27. For the share of solid fuels (mostly coal) in energy end consumption also huge differences are observed between EU Member States, with a mere 0.3% in the Netherlands and 15.6% in Poland. The huge share of petroleum products in the energy consumption mix is to a large extent explained by their prominent role as transport fuels and industrial heating fuels: the industry sector and the transport sector represent 32% and 28%, respectively, of the overall EU 27 final energy consumption, while the share of households is only 24% (European Commission, 2019). These figures help us to understand the enormity of the decarbonisation challenge. While the EU is on track in view of its renewable energy targets for 2020, as shown in Fig. 1, a considerable gap needs to be bridged to reach the 32% goal for renewables in 2030, besides a 40% reduction of greenhouse gas emissions. The newly proposed European Climate Law

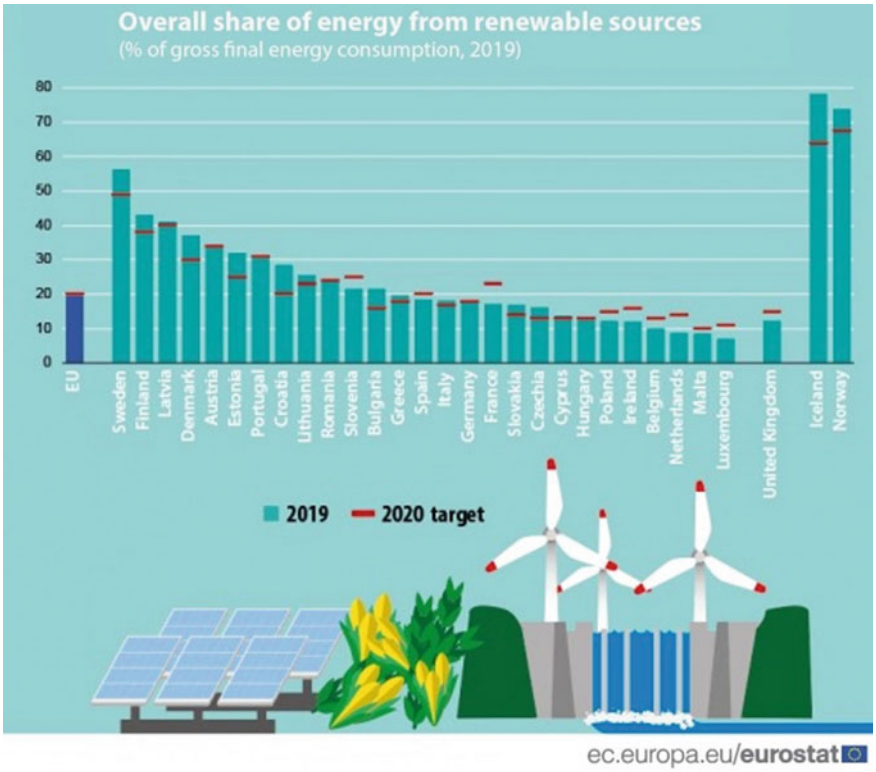

Fig. 1 Share of energy from renewable sources, 2019 (% of gross final energy consumption). *Source* Eurostat (2020)

is even raising the ambition level of greenhouse gas emissions reductions from 49 to 55% in 2030 (compared to 1990 emission levels).

The annual monitoring reports of the World Economic Forum (WEF) on how countries around the globe are "Fostering Effective Energy Transition" reveal large differences between countries in energy transition readiness and progress towards a sustainable, affordable, secure and reliable energy system (World Economic Forum, 2020). Also, within the group of the world's largest energy consumers, the WEF finds big differences in energy transition performance. While India and China show a steady improvement, the performance indicators for the United States and Brazil are declining. This is a reason for concern, as a successful and timely global scale energy transition hinges on the performance of the largest energy consumers and their willingness to lead the transition. A glimmer of hope may be found in the observations that the gap between the top energy transition performers and the rest is steadily decreasing, that the energy intensity of GDP is generally lower in rich countries and that the energy intensity of GDP on a global scale has declined over time (Stern, 2018; World Economic Forum, 2020).

Access to affordable and reliable energy services is an essential condition for economic development and wellbeing. This goes for national economies and for individual citizens. A lack of access to affordable and reliable energy services deprives citizens of opportunities to engage in personal development and economic activity, even in many social activities. In other words: energy access is a crucial condition for an inclusive society. As already discussed, we are still far from catering for an inclusive society for the world population in terms of energy access. The correlation between energy consumption and GDP per capita is shown in Fig. 2, which furthermore reveals large differences in per capita energy consumption between different countries and world regions, and therewith in development opportunities for the population (IEA, 2017).

Energy consumption is connected to income, but the link is loose and variable over time; many countries reach a point where they can reduce energy use and continue to

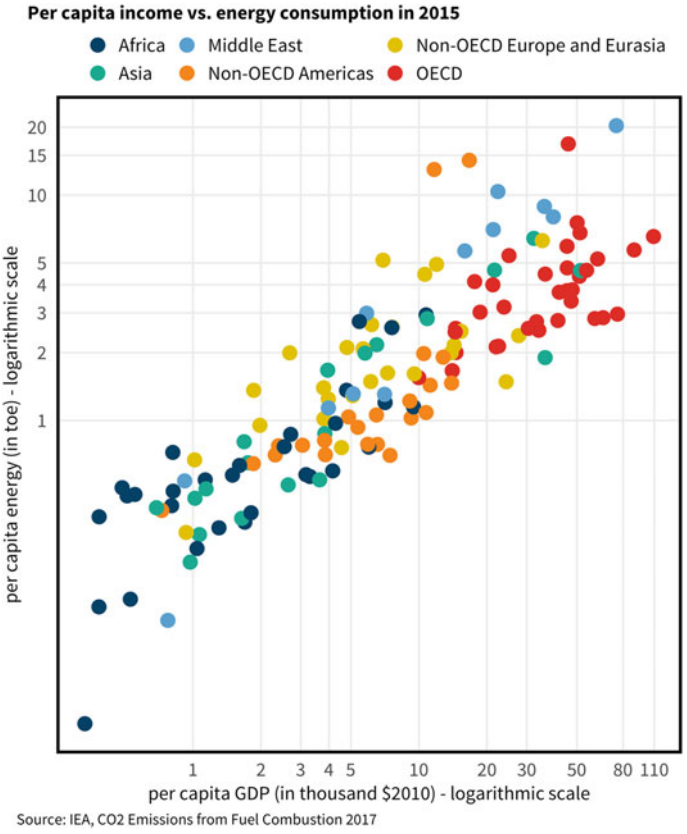

Fig. 2 Correlation of energy consumption and GDP per person; the graph shows per capita energy consumption (in tonnes of oil equivalent) versus per capita GDP (in thousand $2010). All values refer to the year 2015 (IEA, 2017)

grow economically. There is a clear link between per capita energy demand and per capita gross domestic product (GDP) as can be seen in Fig. 2: there are no developing countries that use a lot of energy per capita, and there are no developed countries that consume as little energy as the developing ones. But beyond that, the relationship is hard to define. Countries with similar incomes often consume two, three, four, or five times more energy between them (note the scale is logarithmic). It is similarly common for countries with vastly different incomes to use the same amount of energy. GDP matters, in other words, but so does climate, economic structure, whether energy is taxed or subsidized, technology, policy, and so on (Tsafos, 2018).

Today's situation of almost 800 million people without access to electricity and many more without access to clean fuels for heating and cooking can thus be seen as a case of energy injustice, and it can be considered a moral imperative to remedy this injustice. In practice, lack of access to energy services can be attributed to different causes requiring different solutions. It is not only a problem of poverty; in many developing countries, also people who can afford electricity services are not given physical access to the supply. In such cases, structural issues are often at play, such as inadequate policy and lack of infrastructure. In developing economies, we often see a pattern where electricity infrastructure is provided in the cities, while the less densely populated rural areas are lagging behind. In developed countries, issues of energy access are generally not due to a lack of physical access. Rather, they pertain to the affordability of energy services. That is why the term energy poverty is often used, which is an indicator related to the pressure of energy costs on the disposable household income. Most countries use a threshold of 10% of the household income to indicate energy poverty. Energy poverty is a widespread problem in developing and in developed economies alike. Even in OECD[1]-economies, around 200 million people suffer from energy poverty according to IEA estimates (OECD/IEA, 2017), that is more than 15% of the total population. For the energy poor in OECD countries, energy poverty is often related to the poor quality of their homes, which implies high heating costs to reach a minimum standard of comfort in cold times, if it can be reached at all.

As the world stands, the provision of reliable and affordable energy services is not yet a given for all nations and world citizens. Where such services—and other essential infrastructure services—are lacking, socioeconomic development is impeded. Stark differences in development opportunities by region may contribute to massive migration flows with potentially destabilising consequences. Even within developed economies, large differences in personal development opportunities between groups of the population are a recipe for instability. Access to energy services is one of the conditions, like access to other infrastructure services, for citizens to engage in personal development and economic activity, in other words, to contribute to society and create an inclusive society. That is the compelling reason to act in pursuit of the UN Sustainable Development Agenda at the global and at the local level.

[1]Organisation for Economic Co-operation and Development is an intergovernmental economic organisation with 37 member countries, founded in 1961 to stimulate economic progress and world trade. www.oecd.org.

Sustainable Energy

The energy transition is about more than providing access to energy services to all world citizens. It is also about the sustainability of energy services. It is about preserving the quality of the living environment and the regenerative capacity of the natural system. In the previous century, policy ambitions were predominantly focused on reducing local and regional impacts of the energy system on public health, safety and the natural environment, such as caused by emissions of particulate matter, SO_x and NO_x emissions to the atmosphere, solid waste and emissions to surface waters. Since then, policy focus has shifted to combating climate change, as science has provided compelling evidence that the progressive large-scale exploitation of fossil fuels since the industrial revolution is to blame for climate change unfolding at an increasingly rapid pace. Due to the abundant combustion of fossil fuels, the carbon dioxide concentration in the air we breathe has increased from 300 ppm, before the industrial revolution, to more than 400 ppm today. As a consequence, the natural greenhouse effect of the earth's atmosphere is increasing to levels where the future liveability of our planet for human beings is at stake. A glimmer of hope that the Anthropocene may not be a prelude to the end of human life on our planet, may be found in the truly global scale of climate policy action, as embodied in e.g., the Kyoto protocol and the more recent Paris agreement. Although the effectiveness of global climate policy may be questioned, it is one of the very few examples, like the establishment of the United Nations itself, where so many countries worldwide have agreed to overcome purely national interests and join in a concerted effort for a global cause (UN, 2015b).

Today, as we have come to realize that CO_2 emissions resulting from the combustion of fossil fuels are to blame for the threat of climate change at a global level, policy focus has shifted to decarbonising the current energy system and accomplishing a transition towards a system based on renewable energy resources. Both are formidable challenges which can greatly be facilitated by a structural reduction of energy demand in all sectors of the economy and society. Since energy use is deeply embedded in the routines and structure of all sectors of the economy, this is a difficult challenge in itself. A structural reduction of energy demand that goes beyond energy efficiency measures not only requires massive investment, but also the adoption of new design principles in systems, buildings and processes, and behavioural change in many of our daily routines. Decarbonisation of the energy system can only be achieved by carbon capture and sequestration as long as fossil fuel resources have not yet been replaced by renewable energy resources. Meanwhile, even though the installed renewable energy capacity is growing at an impressive pace, the supply of renewable energy services can hardly keep up with the increasing global energy demand.

Another driver for the transition towards renewable energy resources is the wish to reduce our exposure to the geopolitical risks and vulnerabilities that are inherent to the skewed geographical distribution of fossil fuel resources (Bartuška et al., 2019; Correljé & van der Linde, 2006). Especially oil reserves are controlled by a limited

number of countries, most of them represented in OPEC, which holds the potential of market power abuse. Another vulnerability is posed by the oil transportation routes. Oil carriers using shipping routes through narrow straits and oil pipelines crossing politically instable areas are potential targets for terrorist attacks. Disruption of oil supply chains can potentially disrupt oil dependent economies. This dependence is especially strong in the transportation sector, as the high energy density transportation fuels currently used in aviation, shipping and heavy road transport are all derived from oil. Another sector characterized by a high dependency on oil (and other fossil fuels) is the process industry, as many base chemicals (many of which are derived from oil) and base metals require high temperature processes.

In hindsight, it is too easy to judge the use of fossil fuels, even their current use, as irresponsible now that we have become aware of the potentially dire consequences. Thanks to the industrial revolution, large parts of the global population have been lifted out of poverty. It is largely thanks to fossil fuels that reliable energy services have come within reach of most of the global population, in terms of physical access and affordability. It is a challenge to stage the transition to a truly sustainable climate neutral energy system in such a way so as not to thwart the development opportunities for countries and individuals which have thus far been deprived of such opportunities.

Transition or Disruption?

In using the term energy transition, it is generally assumed that the change process from a fossil fuel-based energy system to a sustainable energy system can be organized and managed in an orderly fashion. There seems to be an implicit assumption that the transition can, at least to a large extent, be designed as a sequence or constellation of technological innovations and behavioural changes, which can be forged by appropriate policy measures, e.g., incentives and regulations. The idea of transition does not deny the need for radical change, but presupposes that social and economic disruption can be avoided.

The assumption of a manageable transition may need to be re-examined in the light of the crises faced by the world in the twenty-first century, such as the financial and economic crises of the first decade and the social and economic crisis caused by the Covid-19 pandemic today. As it turns out, the pandemic is exacerbating the socioeconomic inequalities in the world, between nations, and within nations between segments of the population.

As it grapples with the unprecedented health emergency triggered by the Covid-19 pandemic, the world is experiencing its worst economic shock since the 1930s. This is having a severe impact on employment and investment across all parts of the economy, including the energy sector. Due to long periods of quarantine in many countries all around the world, the energy consumption and production patterns have also changed. An analysis by Wärtsilä Energy Transition Lab for the period March to April 2020, reveals that, compared to the same period in 2019, the coal fired power generation in Europe has been reduced by 29%, the CO_2 intensity was reduced by

20%, the share of renewable generation increased by 8%, reaching 46% in the total energy mix, and finally the energy demand was reduced by 10% compared to the same period in 2019 (Wärtsilä Energy Transition Lab, 2020). At the same time, the world experienced a drastic crude-oil price reduction in April 2020, due to political disagreements between OPEC countries as well as the demand reduction caused by the Covid-19 pandemic.

Governments have taken the lead in providing urgent financial and economic relief to prevent the crisis from spiralling further downward [cf. (BBC News, 2020; German Federal Ministry of Finance, 2020; Government of the Netherlands, 2020; Magazine, 2020]. "Today, attention is increasingly focusing on how to bring about an economic recovery that repairs the damage inflicted by the crisis while putting the world on a stronger footing for the future," as stated by the IEA Executive Director (IEA, 2020d). To assist a quicker recovery, IEA has published a plan in June 2020 (IEA, 2020d). The recovery plan suggested by IEA is focused on three main goals: boosting economic growth, creating jobs and improving future sustainability and resilience of the energy system. As shown in Table 1, they have analysed a range of energy-related measures, which countries could adopt in their recovery plans.

Furthermore, to help repair the economic and social damage caused by the coronavirus pandemic, the European Commission, the European Parliament and EU leaders have agreed on a recovery plan that will lead the way out of the crisis and lay the foundations for a modern and more sustainable Europe (European Commission, 2020). Based on the achieved agreement, more than 50% of the supporting fund goes to innovation and research, climate and digital transition, and health facilities. It is noticeable that 30% of the EU funds is dedicated to climate change mitigation activities, the highest share ever of the European budget. Moreover, in the NextGenerationEU, which is a €750 billion temporary recovery instrument to help repair the immediate economic and social damage brought about by the pandemic, one of the focus points is supporting the Member States with investments and reforms to reach their climate policy goals (European Commission, 2020).

The pandemic has both negative and positive effects on the energy transition. Its negative impact is related to a massive increase in uncertainties which resulted in many investment projects being put on hold. The potential long-term consequence of a substantial delay in investments is utter failure to fulfil the climate targets both worldwide and at the country-level. That is why the recovery plans of many countries entail the provision by governments of large amounts of investment capital to support new and ongoing energy transition projects (see for instance (BBC News, 2020; German Federal Ministry of Finance, 2020; Government of the Netherlands, 2020; Magazine, 2020)). On the other side, in the perspective of the energy transition, the pandemic also brings positive effects in terms of reducing energy demand, coal consumption and CO_2 emissions. The challenge now is to maintain these downward trends in the post-Covid-19 era, and to continue working on achieving the planned targets. Moreover, as suggested by the IEA recovery plan, the energy transition will create new employment opportunities in the field of energy efficiency, renewable

Table 1 IEA energy sector measures to be considered in the recovery plan by the governments (IEA, 2020d)

Sector	Measure
Electricity	• Expand and modernise grids • Accelerate the growth of wind and solar PV • Maintain the role of hydro and nuclear power • Manage gas- and coal-fired power generation
Transport	• New vehicles • Expand high-speed rail networks • Improve urban infrastructure
Buildings	• Retrofit existing buildings and more efficient new constructions • More efficient and connected household appliances • Improve access to clean cooking
Industry	• Improve energy efficiency and increase electrification • Expand waste and material recycling
Fuels	• Reduce methane emission from oil and gas operations • Reform fossil fuel subsidies • Support and expand the use of biofuels
Strategic opportunities in technology innovation	• Hydrogen technologies • Batteries • Small modular nuclear reactors • Carbon capture, utilisation and storage

energy production, infrastructure and services, and in research, development and innovation.

The Way Forward

Access to energy services, and the availability and affordability of energy services, are crucial conditions for social and economic development, for individual citizens and society as a whole. At the same time, these crucial services must be acceptable for society, which is to say that they must comply with the values and priorities of society. Over time, these values and preferences are changing. For a long time, acceptability of energy services was more or less synonymous with health, safety and environmental

issues that could largely be solved by technological means. Today, societal priorities have come to include the combat of climate change, and the meaning of acceptability has come to include issues of equity, fairness and justice. At the most fundamental level, it is this change in societal values and priorities which is steering the energy transition.

In the pursuit of the energy transition it is a major challenge to connect technological change to the social values at stake. The feasibility of the energy transition hinges on public acceptance of the massive investments required as well as the behavioural changes called for in the way we use energy. Energy services are necessary to enable economic activity and to support us in our daily routines, in virtually everything we do, not only as economic agents, but also as members of social communities to which we contribute. This awareness is crucial for all involved in the energy transition to acknowledge its social dimension, beyond the technological challenge. Rather than deepening existing social divides or causing new rifts, we all have a moral obligation to shape the energy transition in such a way as to support a more inclusive society.

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